REMARKS

Applicants appreciate the time taken by the Examiner to review Applicants' present application. This application has been carefully reviewed in light of the Official Action mailed May 21, 2003. Applicants respectfully request reconsideration and favorable action in this case.

Claim 42 is rejected under 35 U.S.C.§ 112(2) as indefinite. Claim 42 is amended to depend from independent apparatus claim 34, thereby obviating the lack of antecedent.

Accordingly, withdrawal of this rejection is respectfully requested.

The Huang (i.e., U.S. Pat. No. 6,067,292) Rejections

Claims 1-13 and 23 are rejected under 35 U.S.C. §103(a) as obvious over U.S. Patent No. 6,067,292 issued to Huang in view of U.S. Patent No. 6,104,748 issued to Kaku.

Huang **does not** disclose or suggest down converting an RF signal from a center frequency f_{RF} to an intermediate center frequency f_L, where f_L is greater than or equal to the CDMA chip rate, f_c. Specifically, referring to Huang, Fig. 2, elements **202** and **203**, form a quadrature demodulator that brings the RF signal from a center radio frequency down to base band or, equivalently, to a center frequency of 0, i.e. dc.

The fact that Huang **does not** disclose or suggest down converting an RF signal from a center frequency f_{RF} to an intermediate center frequency f_L, where f_L is greater than or equal to the CDMA chip rate, f_c. is also evidenced up by the statement in Huang at col. 4 lines 19-22 that:

> The outputs of down converters **202** and **203** are each filtered by an anti-aliasing LPF (**Low Pass Filter**) **204** and **205**, respectively, to produce a resulting **baseband** I and Q signals. (Emphasis added).

Huang **does not** disclose or suggest using a **bandpass** filter to remove extraneous signals while passing said CDMA pilot channel signal. Huang specifically calls out for **low pass**

filters (two filters, one for the in-phase and one for the quadrature). It is well known to those familiar with CDMA receivers that the lowpass filter outputs contain all the CDMA signal components including data as well as pilot signals as well as multi-path versions thereof. Huang ascertains the parameters of the pilot signal, and its multi-path variants, and **synthesizes** what the received pilot signal would look like (actually an estimate of the received pilot signal) in each of the multi-path embodiments and "removes" the pilot contribution to the data path by subtraction of this **synthesized** version.

Huang does not teach the use of a **single** analog to digital (A/D) converter. With reference to the cited Fig. 3, elements **301** and **302**, col. 4 lines 55-57, it is clear that Huang teaches the use of **two** A/D converters, one for the I component and one for the Q component.

Kaku describes spread spectrum signal receiving apparatus. The fundamental invention in Kaku is the reduction in complexity afforded by replacing the early/late correlation apparatus of a conventional receiver (e.g. see Fig. 4 of Huang) with a single nominally on-time correlation circuit and making two readings of the pilot (on-time) correlation in complex form. The premise is that the frequency output of the VCO is correct when the two complex readings have the same phase angle (col. 5, 33-67; col. 6, 1-29).

Some important observations on Kaku include the following six points.

First, the RF demodulation of Kaku is performed using quadrature carriers [$\cos(\omega_c t)$ **and** $\sin(\omega_c t)$] (see Fig. 1, Fig. 2 and col. 4 line 65 to col. 5 line 2 of Kaku) to bring the desired channel to baseband in the form of *in-phase* (I) and *quadrature* (Q) signals. Presumably, anti-aliasing lowpass filtering is applied in anticipation of A/D conversion.

Second, each of the I and Q paths of Kaku requires an A/D converter. This is clearly shown in Fig. 3 of Kaku which shows **two** A/D converters, $\mathbf{5_1}$ and $\mathbf{5_2}$.

Third, the accumulation (integration) required for the correlation operation of Kaku is done over exactly one symbol period. This can be inferred from (col. 7, 18-22) where it states

that "dispreading correlation demodulators **7_1** to **7_4** differ from each other in the used signals and PN codes sequence but have the *same circuit structure*" (emphasis added). Since the correlation for the data signals must necessarily be over an interval less than or equal to the symbol interval, the inference follows.

Fourth, the receiver of Kaku tracks just one pilot channel and makes no provision for multi-path.

Fifth, the notion in Kaku of what is "t" and what is "Δt" is somewhat vague. It seems reasonable, however, to assume that Ip(t) and Qp(t) (see col 5, third paragraph) refer to the output of the accumulators (see Fig. 6 or 9, elements **10_1** and **10_2**) and these have valid contents at the end-points of symbol intervals. Similarly, Δt is one symbol interval. Thus Ip(t) and Ip(t+Δt) refer to two consecutive accumulation results for the in-phase path and similarly for the quadrature path.

Sixth, the receiver of Kaku is otherwise a conventional tracking receiver except that it uses sequential estimates of the complex-valued on-time correlation for determining movement of time base after the pilot epoch has been established.

Whereas Huang does employ a complex correlation circuit (Fig. 4, elements **402** and **404**, Fig. 5, element **504** (for the pilot), col. 5 lines 20-35 and col. 6, lines 30-67), it must be emphasized that Huang's correlators are conventional **complex** accumulators that accumulate N_c products (obtained by multiplying the complex baseband signal, $r = I+jQ$, with the complex form of the I-channel-cum-Q-channel PN sequences) per correlation sample. In contradistinction, the inventive correlator, called the Offset Carrier Correlator (see page 17 of this application) makes special use of the particular choices of sampling rate, chip rate, and down-converted center frequency, f_L, to establish a correlator structure that is extremely efficient. In particular, the conventional scheme taught by Huang cannot make use of the mathematical property expressed in the equations on page 20 of the instant application.

The error signal that Huang uses to discipline an oscillator is not described, but merely implied. Considering that Huang is related to canceling the contribution of the pilot signal and multi-path versions thereof, it is clear that the frequency control mechanism is based on conventional CDMA receivers. This is clear from Fig. 4 of Huang, specifically element 403, that depicts a *Complex Correlator (Pilot Early/Late)* (also see Kaku, Fig. 2C and Kaku col. 2 lines 40-61). The Examiner's citation of col. 17, lines 16-25, does not actually refer to a frequency error but, rather, to an error term associated with the removal (synthesis and subtraction) of pilot components from the data (information) signal path. In conventional frequency control methods, the output of the early/late correlator is an indication of time offset between the local (within the receiver) time origin (epoch pertaining to the start of the PN codes used) and that of the transmitter manifested at the receiver. Frequency control is achieved by adjusting the local time-base continually such that the early/late correlation value is close to zero, constrained by the condition that the on-time correlation should be large (at or close to maximum). This is in sharp contrast to the methodology used by the claimed inventive receiver. In the claimed inventive receiver the time-of-arrival, or, equivalently, *pilot position*, is derived, in each measurement cycle, by establishing a correlation profile and from the maximum value ascertaining the pilot position with respect to the local *Master Counter* (see page 21/37, first paragraph). These pilot positions (there could be multiple pilots being tracked) are fed to the main processor for purposes of disciplining the (local) oscillator, typically a Rubidium atomic standard or high-quality quartz standard.

The Examiner states that "Kaku teaches generating an estimate of a frequency error using correlation values corresponding to (2M+1) time shifts...and M is greater than or equal to 1 (citations omitted)". However, this is not correct. Kaku teaches the use of **two**, presumably consecutive, estimates of the **on-time complex correlation**. The frequency error is estimated by the difference in angle (also referred to as "argument" in the literature on complex numbers).

The reference to col. 6, lines 38-42 reinforces my conclusion that the correlation estimates correspond to *on-time* calculations. With reference to our disclosure, page 19/37, we show that the true complex correlation shows how the phase difference between the local carrier and the transmitter carrier, ϕ, gets introduced. Kaku rightly concludes that a frequency difference will be discerned as a changing value of ϕ. The equation provided in Kaku, col. 6, line 14, is somewhat misleading. Instead of $\theta(t)=2\pi f(t)$, a more correct equation is $[\theta(t+\Delta t) - \theta(t) = 2\pi.\Delta f.\Delta t]$ though the spirit of Kaku's equation, namely that the angle changes with time in a linear fashion depending on frequency (offset) is quite appropriate. In the inventive correlator, the (2M+1) correlation estimates are considered in **magnitude** to eliminate the possible error in phase (see page 19/37) and are representative of correlation values for a multiplicity of time lags and the maximum value is considered to be representative of the on-time correlation which in turn establishes the relative position of the PN code with respect to the *Master Counter* (local time). This on-time index in the K-th measurement cycle is referred to as D(K) and when the frequency offset is zero, D(K) will be constant from measurement cycle to measurement cycle.

The Examiner states that "[a]s per claims 2-4, the method of Huang does includes a sampling rate, Fs, an intermediate center frequency, f1, and a chap rate, fc. Furthermore implementing the Fs, f1, and fc to be related by Fs=4fc and F1=fc+kFs would have been obvious to one skill in the art in order to accurately remove noise in the pilot channel signal." However, this is not correct. Huang very definitely uses conventional quadrature demodulation with two low pass filters and two A/D converters which implies that f_L is **zero** (dc). Huang does teach the notion of sampling at a rate of $\rho.f_{chip}$, but the reason for doing so is to establish ρ different sampling phases for the RAKE receivers. Very specifically, Huang teaches (see col. 6, lines 41-45) that "picks one out of ρ samples per chip for further processing". That is, the A/D converter is being used as a converter operating at sampling rate f_{chip}, but with multiple possible sampling phases.

The Examiner states "[a]s per claim 5, the method of Huang does include a single accumulator for generating both real and imaginary (citations omitted)." Examiner is correct in his assertion that there is a single **complex** accumulator taught by Huang. That would mean that the multiplier (Fig. 5, element 503) is complex-valued and thus comprises 4 real "multiplies" and two real "additions" (subtraction and addition are considered equivalent operations in a digital signal processing lexicon) and the complex accumulator comprises two real-valued accumulators to handle the real and imaginary parts. In our inventive correlator (see page 20/37) we simultaneously achieve down conversion from center frequency fL to baseband (zero frequency or dc) as well as the accumulation, using two real accumulators as does Huang, but the multiplication is shown to be by either +1 or –1 which is "trivial".

The Examiner states that "[a]s per claim 6, it would have been to one skill in the art to implement the monitoring of both positive overflows and negative overflows into Huang in order to enhance the correlation capability of the channel." There is reason to disagree with this conclusion. In Huang the accumulation is done over one symbol interval, corresponding to N_c terms ($N_c = 64$). The word length growth is therefore limited to less than 6 bits since $64 = 2^6$. In the inventive correlator the accumulation can be done over 2^{17} (and possibly a multiple thereof) corresponding to a word length growth of as much as 17 bits. Considering that typical hardware word lengths are of the order of 16 bits and that A/D word lengths in this type of applications is typically less that 10 bits, the notion of overflow and underflow in Huang is moot; addressing word length growth of 17 bits requires the claimed inventive, non-obvious, designs such as that described on page 16/37 of the instant application.

The Examiner states that "[a]s per claim 7, the method of Huang does include correlation process instead of matched filter (citation omitted)." The Examiner is correct in stating that Huang does not have a matched filter. However, since Huang teaches chip-rate sampling, the notion of a matched filter is moot. Matched filter implications are there only if the

sampling rate is greater than (a multiple of) of the chip rate. If Huang did his processing at a sampling rate of $\rho.f_{chip}$, which he does not, he would have had to deal with a filter (matched or otherwise appropriate) of length ρ, assuming an FIR implementation.

The Examiner states that "[a]s per claim 8, the method of Huang does include a receiver (citation omitted)" While Fig. 2 of Huang does indeed show a receiver, it is clear that the function, structure, implementation methodology, design criteria, and application of Huang's receiver is quite dissimilar compared to the claimed limitations.

The Examiner states that "[a]s per claims 9-10 and 13, it would have been to one skill in the art to implement the correlation computation of time shift lags into Huang in order to achieve better correlation in the channel." However, this is not correct. Although Huang does correlation at multiple time-lags, with each RAKE finger responsible for one time-lag, the time-lags in question are typically fractions of a chip period considering they represent different multi-path delays and it is also true that they represent time-lags that are commensurate with the sampling rate of $\rho.f_{chip}$, where) though the sampling rate is a multiple of the chip rate, subsampling (also known as undersampling, the process of choosing one out of each ρ samples). In the claimed inventive correlator architecture, multiple time-lags are considered from the view of generating a cross-correlation profile to best ascertain the time-position, relative to the local *Master Counter*, of the pilot signal being observed/measured. Huang teaches the use of RAKE fingers which each have a single "on-time" lag and, possibly, another correlator that does a difference (i.e. early/late) for two other lags. This is quite different from synthesizing (i.e. interpolating) between multiple correlation time-lags as required by Claim 10. Furthermore, Huang teaches a tracking receiver where adjustments are made to the phase/frequency of the local time-base **every symbol interval**. The notion of averaging over multiple periods of the PN signals as required by Claim 13 is quite distinct, considering that each PN period is 2^9 (i.e., 512) symbol intervals.

The Examiner states that "[a]s per claims 11-12, the method of Huang does include background correlation (see fig. 4, element **403**)." Examiner probably intended to cite Fig. 3, element **308**, col. 5 lines 9-13. Huang does include a complete RAKE finger receiver that is "spare". This is quite different from the notion of an Autonomous Background Correlator (ABC) (see page 28 of the instant application) which does a correlation over a partial period and over a period that is ***relatively prime*** to the PN period. As a consequence of the relative prime relationship between correlation interval and PN period, each accumulation is appropriate for a different time-lag and these different time-lags encompass all possible choices before repeating.

It is important to note that in a tracking receiver, such as that taught by Huang and/or Kaku, the disciplining of the local time-base and/or the local PN-generator is done "continually" with the intent of keeping the correlation of the "on-time" finger at a maximum. In contrast to Huang and/or Kaku, the claimed receiver measures the arrival time of the pilot signal epoch (the pilot is a periodic signal) with respect to a local Master Counter. In the claimed invention, the local time-base can be disciplined by algorithms that attempt to keep the time-or-arrival constant. Alternatively, by making multiple measurements of time-of-arrival, in the claimed invention an estimate of the frequency offset between the local time-base and the CDMA time-base can be made. This offset can be used to correct (i.e. change) the local time-base. Nevertheless, in the claimed invention it is sufficient for the receiver to operate properly if the local time-base is close (i.e. the frequency offset is small) and proper operation is achieved even if the time-base is not adjusted.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 14-21 are rejected under 35 U.S.C. §102(e) as anticipated by U.S. Patent No. 6,067,292 issued to Huang, et al.

Huang describes pilot interference cancellation for a coherent wireless code division multiple access receiver. The fundamental invention in Huang is a method to detect multi-path pilot signals and subtract a replica thereof from the primary signal, thus improving the signal-to-noise ratio for more robust extraction of data. The primary goal taught by Huang is to subtract the contribution of multi-path versions of the pilot from the base-station transmitting the data (see col. 2, lines 3-7; lines 12-16 of Huang). The pilot subtraction (i.e. cancellation) can be done either pre-demodulation or post-accumulation (see col. 2, lines 26-37 of Huang).

In the pre-demodulation scheme of Huang, the interfering pilots subtraction is performed on the chip-samples (see col. 7, lines 46-48 of Huang). This Huang methodology is an extension of a conventional RAKE receiver. Each finger, **603** and **604**, of Huang is modified to include a pilot reconstruction circuit, **606** and **607**. The recovered pilots, with estimated attenuation, phase, and path delay incorporated, are subtracted from the received signal (on-time path) prior to extraction of data (see col. 7, lines 65-67; col. 8, lines 1-13 of Huang). The same principle applies to the post-accumulation cancellation scheme of Huang which has the advantage of requiring less computational complexity since the calculations are done at the symbol rate rather than the chip rate. Some important observations on Huang include the following four points.

First, the RF demodulation of Huang is performed using quadrature carriers [cos(ω_ct) **and** sin(ω_ct)] (see Fig. 2 and col. 4, lines 16-22 of Huang) to bring the desired channel to baseband in the form of *in-phase* (I) and *quadrature* (Q) signals. Anti-aliasing lowpass filtering is applied by Huang in anticipation of A/D conversion.

Second, each of the I and Q paths of Huang requires an A/D converter. This is clearly shown in Fig. 3 of Huang which shows **two** A/D converters, **301** and **302**.

Third, the accumulation (integration) required for the correlation operation of Huang is done over exactly one symbol period (N_c chips) (see col. 4, line 50 and col. 7, lines 31-34 of Huang).

Fourth, the receiver of Huang is otherwise a conventional tracking receiver that first establishes the position of the pilot epoch and then monitors movement by using the results of an "early/late correlation".

The Examiner states that "[a]s per claim 14, Huang et al discloses an apparatus to track a pilot signal, comprising: a correlator circuit adapted to compute a complex correlation between a received version of the pilot signal and locally generated versions of I-channel and Q-channel PN signals, respectively ..." Although Huang does indeed disclose complex correlators that compute a complex correlation between a received version of the signal and locally generated versions of the I-channel and Q-channel PN signals, it is clear that the type of correlator taught by Huang is exemplified in a conventional RAKE receiver that performs just "on-time" and "early/late" correlations with multiple receivers handling multiple "on-time" values corresponding to different multi-path profiles. The claimed inventive correlation receiver, in contrast, estimates multiple correlation values corresponding to multiple lags commensurate with the sampling rate in order to generate a correlation profile from which the "best" time-of-arrival is ascertained. Whereas the conventional RAKE receiver attempts to discipline the local time-base and/or the PN-generator phase such that the "on-time" correlation value remains at a "peak", the claimed inventive correlation receiver is geared to discern whether the correlation peak (i.e. the "time-of-arrival") has moved since the last measurement and by what amount.

The Examiner states that "[a]s per claim 15, the apparatus of Huang does include a buffer." The Examiner is correct is stating that an FPGA can be used as a buffering or storage device. This is especially true with the Xilinx FPGA family that includes memory (RAM) as a building block available to the circuit designer. However, claim 15 requires that the correlator

include a FPGA not simply as a buffer (i.e. as a memory element) but to implement the various circuit modules such as the PN-generator, adder/accumulator, sequencing logic, and so on.

The Examiner states that "[a]s per claim 17-18, the method of Huang does include a signal processor having a DSP (citations omitted)". Examiner is correct that Huang does teach the use of a Signal Processor embodied in a DSP (Digital Signal Processor). However, a DSP is somewhat generic and it is the algorithms that are being implemented that distinguish the usage. In our inventive receiver, the DSP does post correlation signal processing for the purposes of refinement of "time-of-arrival" estimation; in Huang, the DSP does the post-processing associated with extraction of the information signal embodied in the CDMA signal.

The Examiner states that "[a]s per claim 19, the method of Huang does includes a signal processor for averaging correlation values (see col. 4, lines 26-28)." Examination of col. 4, lines 26-28, shows that Huang teaches the weighted average of the signals from different fingers, which can be considered a "spatial average". In contrast, the averaging in the inventive receiver is a temporal average over multiple measurement cycles. Huang's average is to improve signal-to-noise-ratio for the purpose of extracting information more reliably (in real-time); our averaging is to improve the estimate of time-of-arrival.

The Examiner states that "[a]s per claim 20, the method of Huang does includes parallel correlator (citations omitted)" Although the Examiner is correct in observing that Huang teaches correlators in parallel, it is clear that these parallel correlators are tracking the same pilot/data signal (i.e. they propagate from the same base station) at different multi-path delays. In the claimed inventive receiver, the parallel correlators are tracking different pilot signals from different base stations.

The Examiner states that "[a]s per claim 21 the method of Huang does include background correlation (see fig. 4, element **404**)." Examiner probably intended to cite Fig. 3, element **308**, col. 5 lines 9-13. Huang does include a complete RAKE finger receiver that is

"spare". However, this is quite different from the notion of an Autonomous Background Correlator (ABC) (see page 28 of the instant application) which does a correlation over a partial period and over a period that is ***relatively prime*** to the PN period. As a consequence of the relative prime relationship between correlation interval and PN period, each accumulation is appropriate for a different time-lag and these different time-lags encompass all possible choices before repeating.

The Examiner states that "[a]s per claim 22 the method of Huang does includes a CDMA (citations omitted)." Examiner is correct is observing that Huang does teach the tracking of a CDMA pilot signal. However, this is in view of a conventional CDMA receiver that needs to track the pilot in order that it can establish the appropriate phases for extracting information from the CDMA signal.

Accordingly, withdrawal of this rejection is respectfully requested.

The Feher (i.e., U.S. Pat. No. 6,479,055) Rejections

Claims 24-25, 27-28, and 32-43 are rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No. 6,479,055 issued to Feher.

Feher describes spectrally efficient FQPSK, FGMSK and FQAM for enhanced performance CDMA, TDMA, GSM, OFDN, and other systems. The Examiner cites Fig. 6B, element **6.22**, Fig. 33, element **33.6**, and col. 20, lines 6-18 as "disciplining an oscillator". However, this is not correct. Feher states that the LO (**6.22**) could be free running, implying that there is no disciplining. The alternative is ***carrier recovery***. Carrier recovery is a completely different aspect of radio signal reception. Feher synthesizes the RF continuous-wave (i.e. sinusoidal) signal used by the transmitter as the RF carrier. The sole purpose of this is to allow proper demodulation, by the quadrature demodulator (elements **6.23, 6.24, 6.25, 6.26, 6.27** in Fig. 6B of Feher). This Feher approach is traditional radio receiver practice. It

should be noted that element **6.23** is a "multiplier" or "modulator" which does a frequency translation and is not related to over-sampling or correlating as required by the pending claims.

Accordingly, withdrawal of this rejection is respectfully requested.

Claims 29-31 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,470,055 issued to Feher, in view of U.S. Patent No. 6,104,748 issued to Kaku. Kaku does not obviate the above discussed deficiencies of the Feher reference.

Accordingly, withdrawal of this rejection is respectfully requested.

Claim 26 is rejected under 35 U.S.C. §103(a) as obvious over U.S. Patent No. 6,470,055 issued to Feher, in view of U.S. Patent No. 6,493,378 issued to Zhodzishsky. Zhodzishsky does not obviate the above discussed deficiencies of the Feher reference.

Accordingly, withdrawal of this rejection is respectfully requested.

The form PTO-948 attached to the Action indicates that the drawings filed April 20, 2000 are objected to by the draftsperson under 37 CFR 1.84 or 1.152. Corrected drawings are filed herewith.

Other than as explicitly set forth above, this reply does not include acquiescence to statements by the Examiner. In view of the above, all the claims are considered patentable and allowance of all the claims is respectfully requested. The Examiner is invited to telephone the undersigned (at direct line 512-457-7233) for prompt action in the event any issues remain.

No fee is due for filing this Reply because it is being filed with the shortened statutory period for response as set in the Office Action dated May 21, 2003.

The Commissioner is hereby authorized to charge any fees or credit any overpayments to Deposit Account No. 50-0456 of Gray Cary Ware & Freidenrich, LLP.

Respectfully submitted,

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